Estuarine Modeling

Who Am I?

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- Ms (2002), Civil Engineering, METU

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Who is Drexel?

- Founder, Anthony J. Drexel (1826-1893)
- Drexel Institute of Arts, Science and Industry founded in 1891
- Unlike other Colleges with Gothic detailed Buildings on green lawns, Drexel was placed in urban setting occupying a block adjacent to Railroad and Car Manufacturer
- 1936 Drexel Institute of Technology
- 1970 Drexel University
- 2002 Acquired Medical School

Where is Philly?

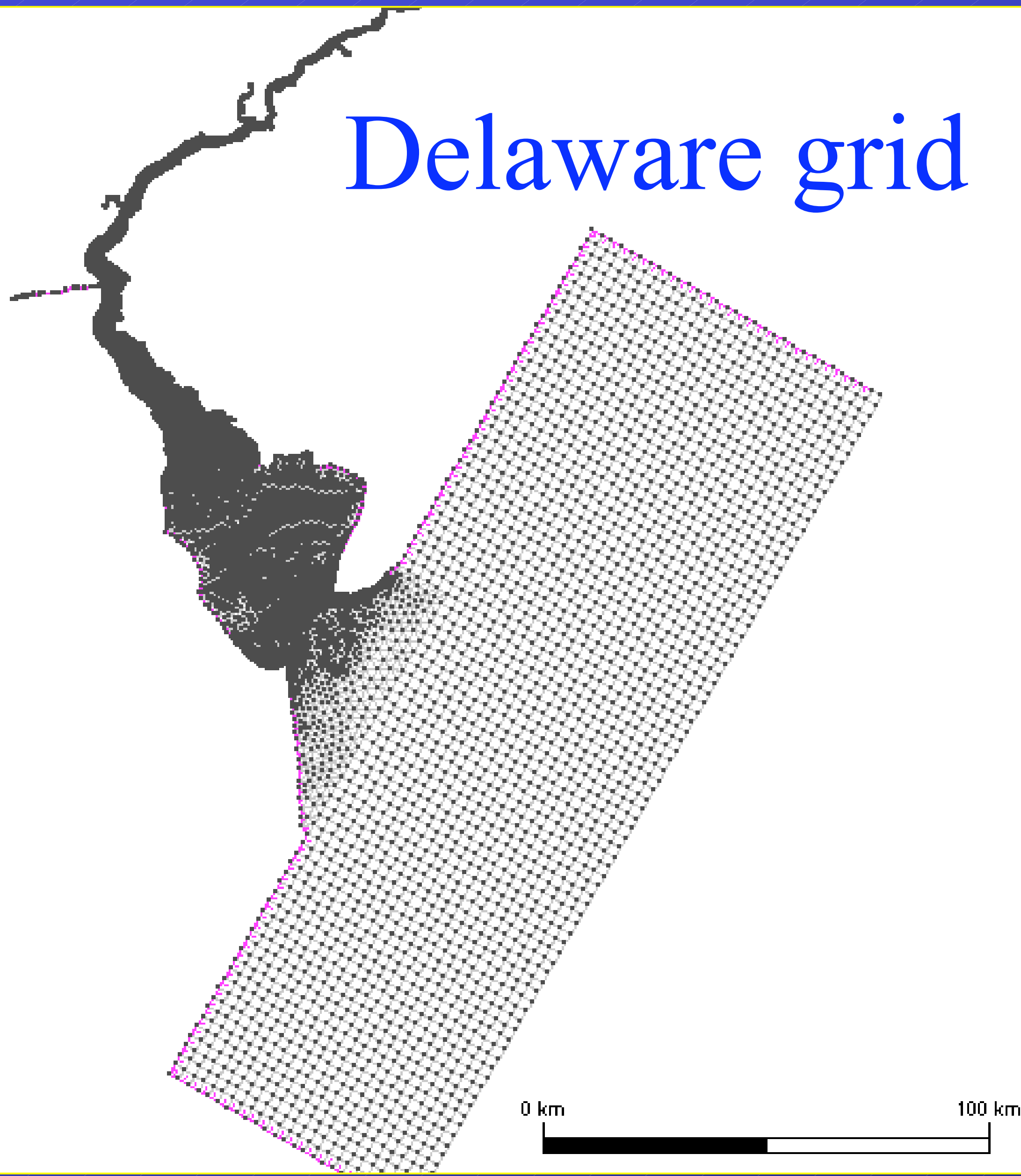
Delaware River/Estuary System

- 330 Miles (550 km) long
- 13540 sq.-miles watershed
- ~15 million people rely on the Delaware for drinking water
- nearly 5% of US population for only 0.4% continental land mass of US
- Delaware River Port Complex is largest fresh water port in the world
- Part of the National Estuary Program for protection of nat'l significant estuarine systems

Delaware Estuary

The Delaware Estuary is located in the Mid-Atlantic region of the United States, and includes portions of Pennsylvania, New Jersey and Delaware, through which the Delaware River flows.

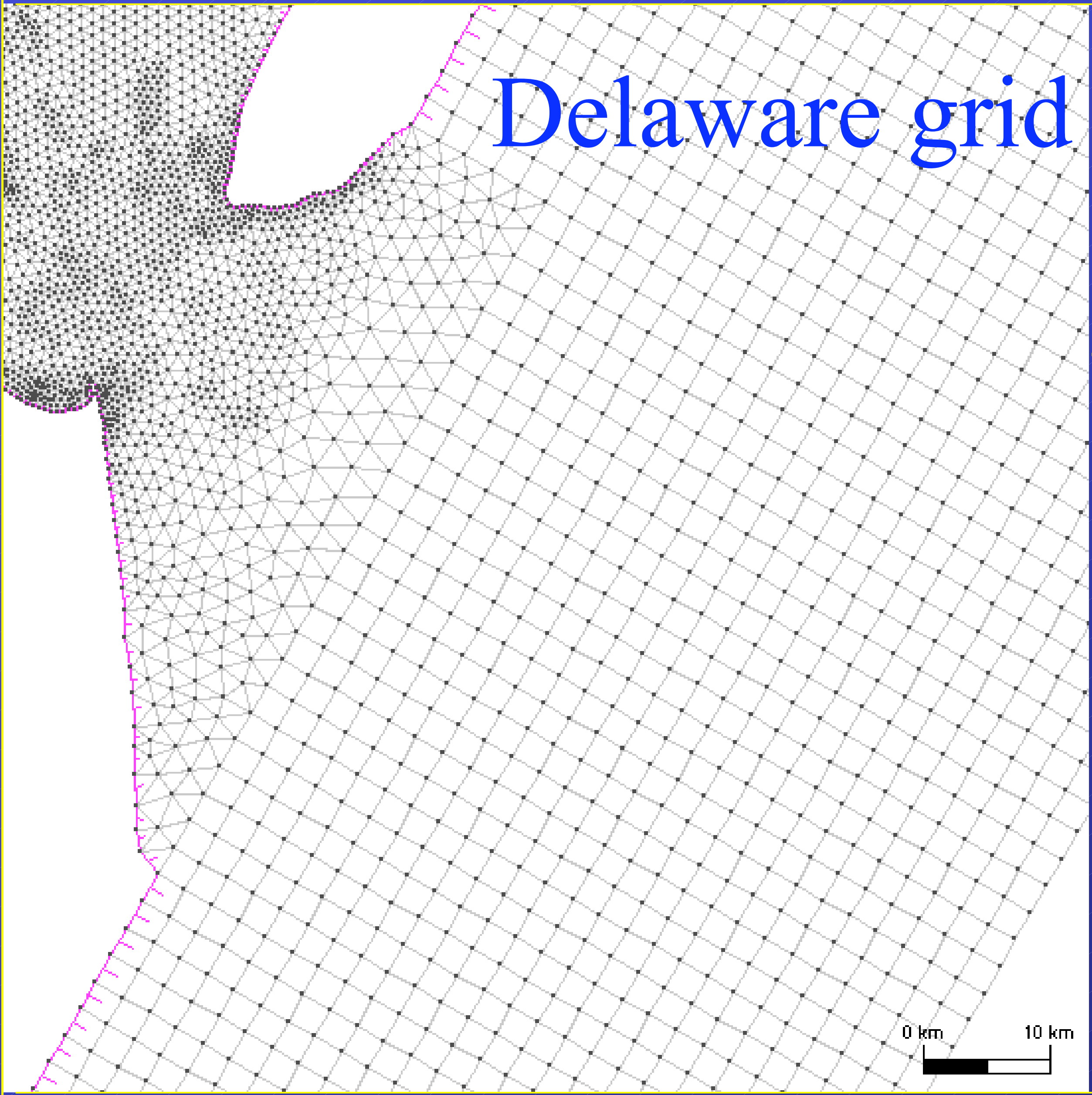
Delaware grid



2-D Grid Properties

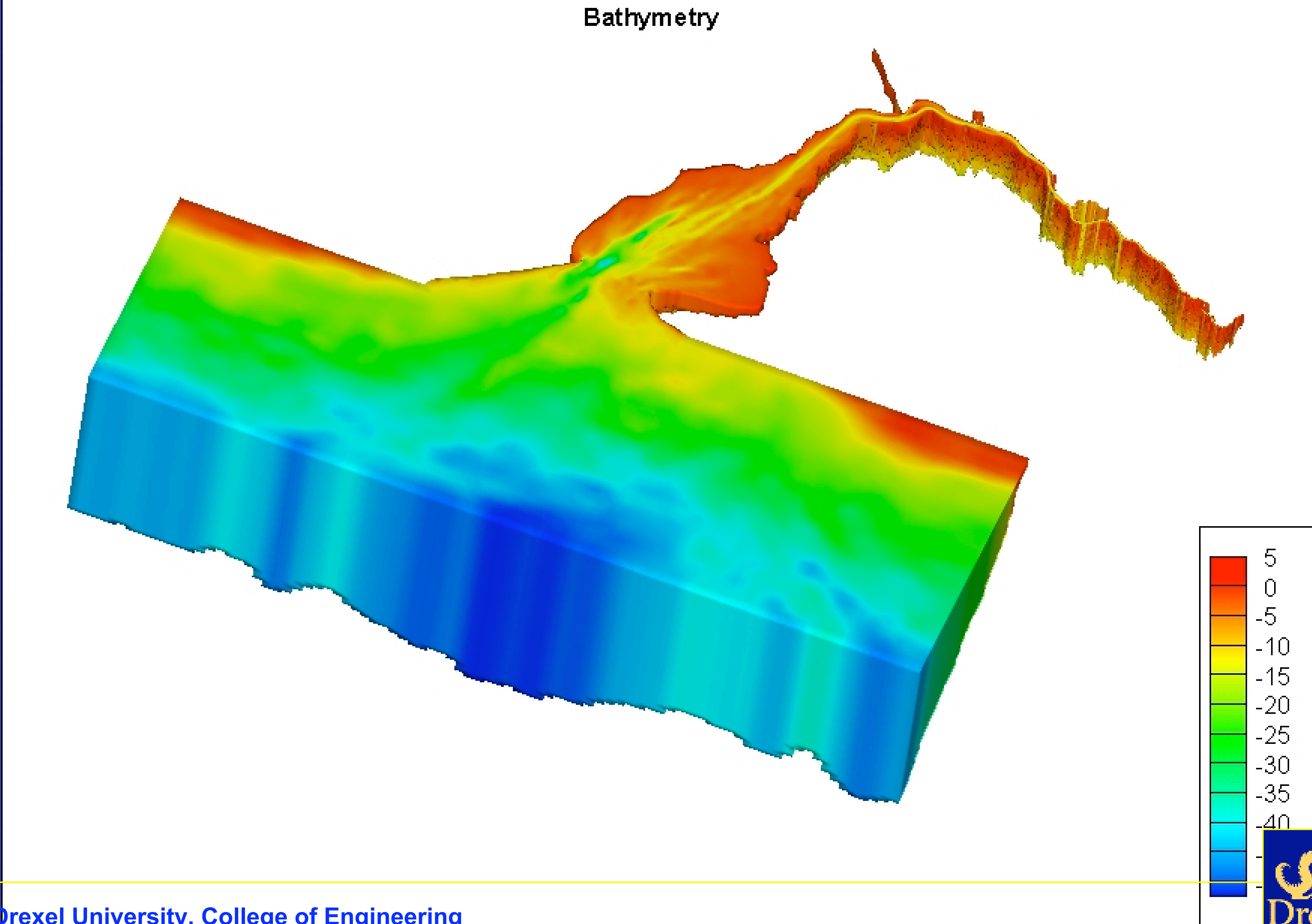
- # element = 49218
- # side = 77870
- # nodes = 28643
- # boundary el.= 90

Delaware grid

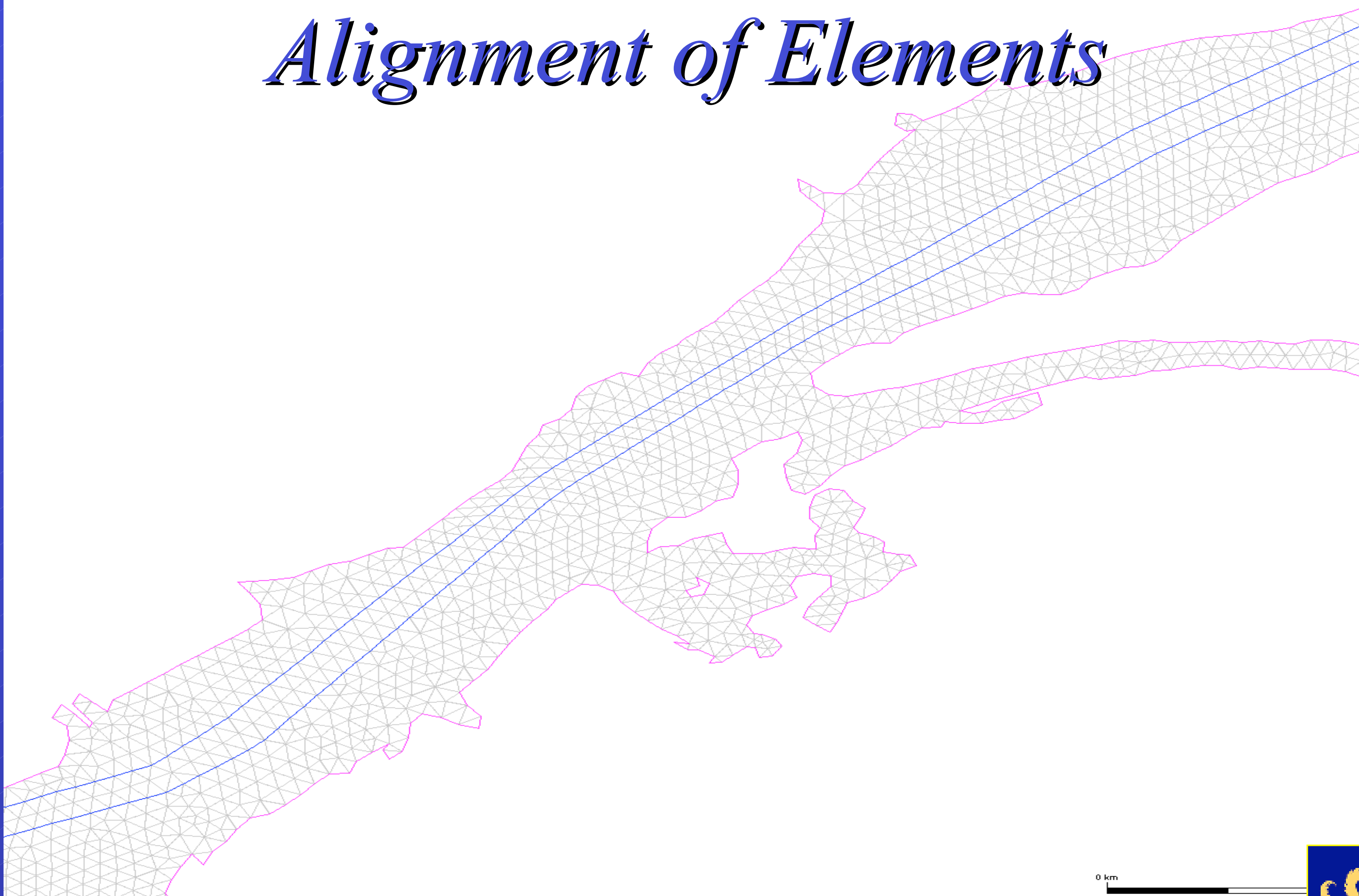


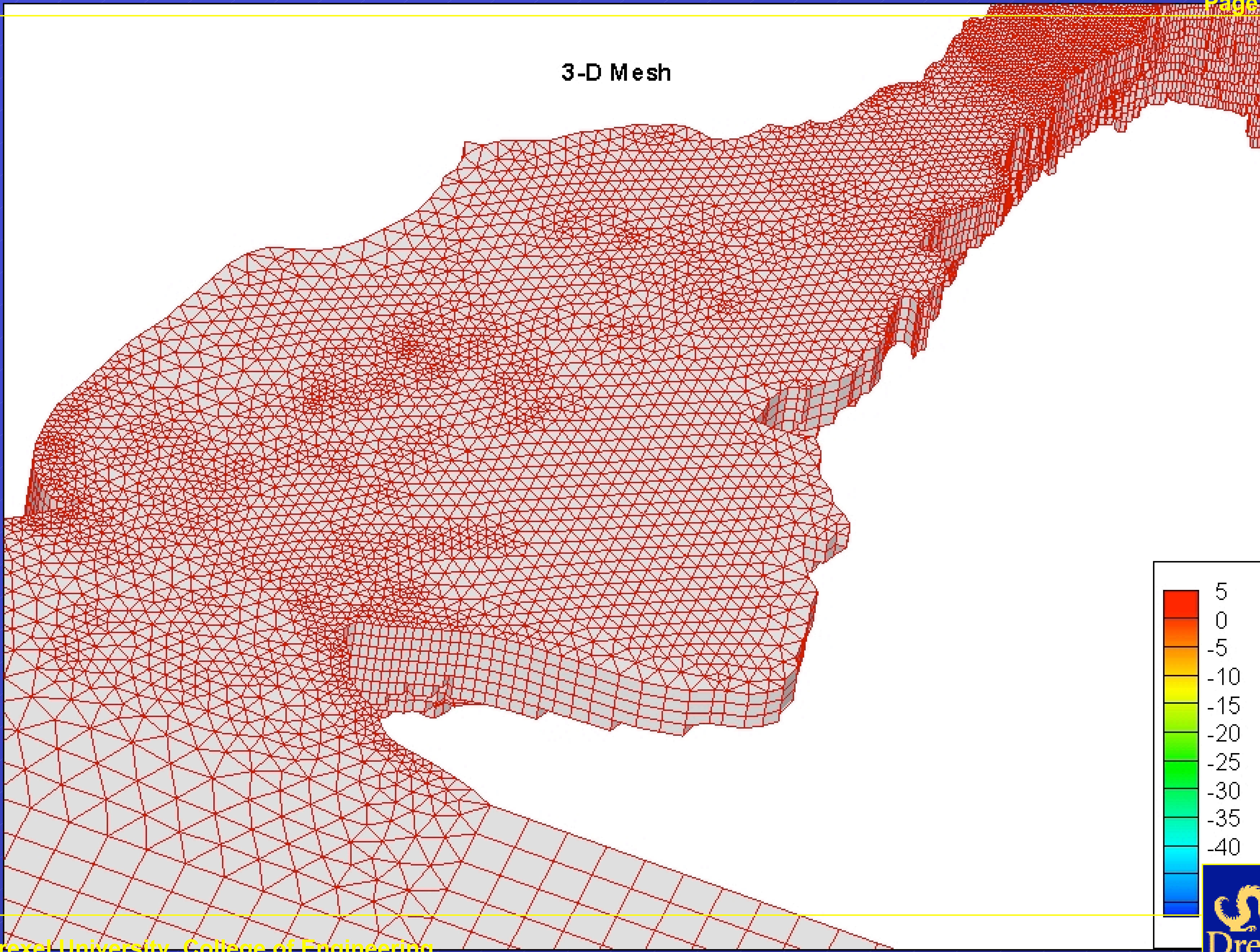
3-D Grid Properties

- # Layers = 60
- # element = 557404
- # side = 928705


Bathymetry
5
0
-5
-10
-15
-20
-25
-30
-35
-40

Alignment of Elements



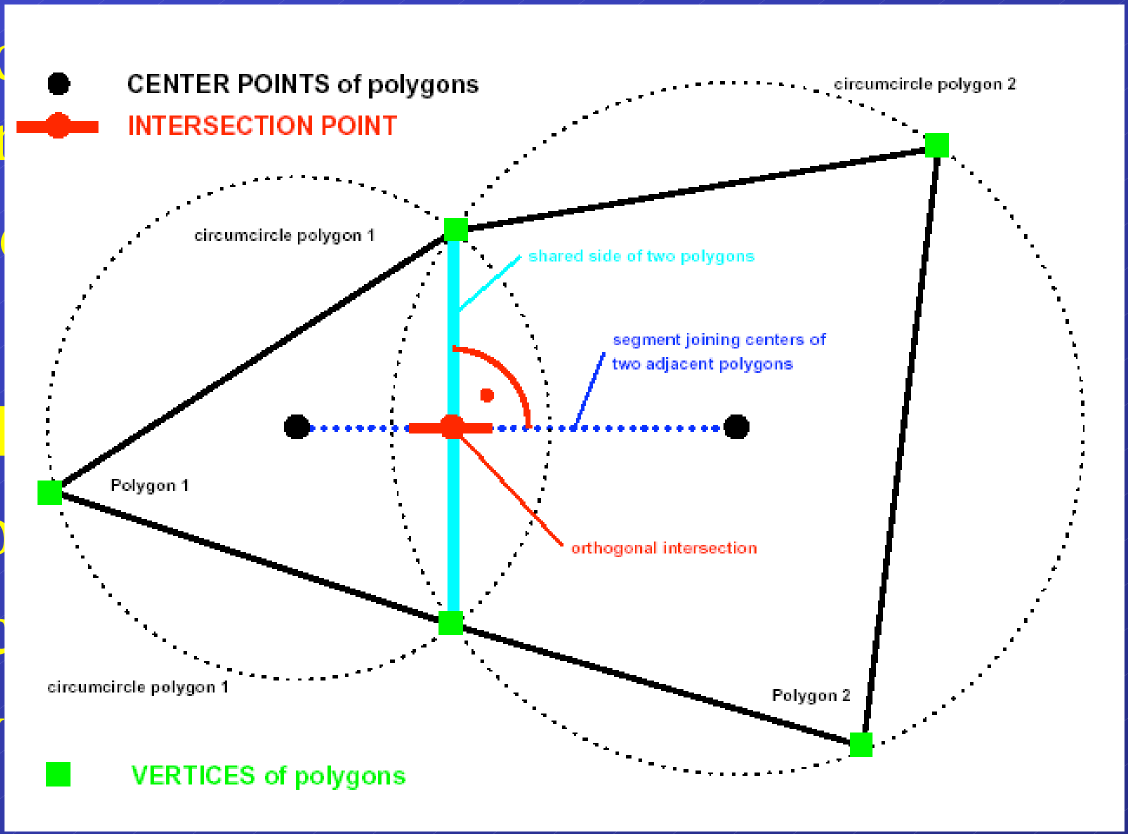

3-D Mesh
5
0
-5
-10
-15
-20
-25
-30
-35
-40

Need for a 3D Numerical Model

- Complex Circulatory patterns
- Bay is (partially) stratified (salinity)
- Very shallow areas (drying/wetting)
- Deep Navigation Channel (dredging)
- Erosion/Re-suspension Patterns are complex and require vertical velocity profiles

Properties of Untrim

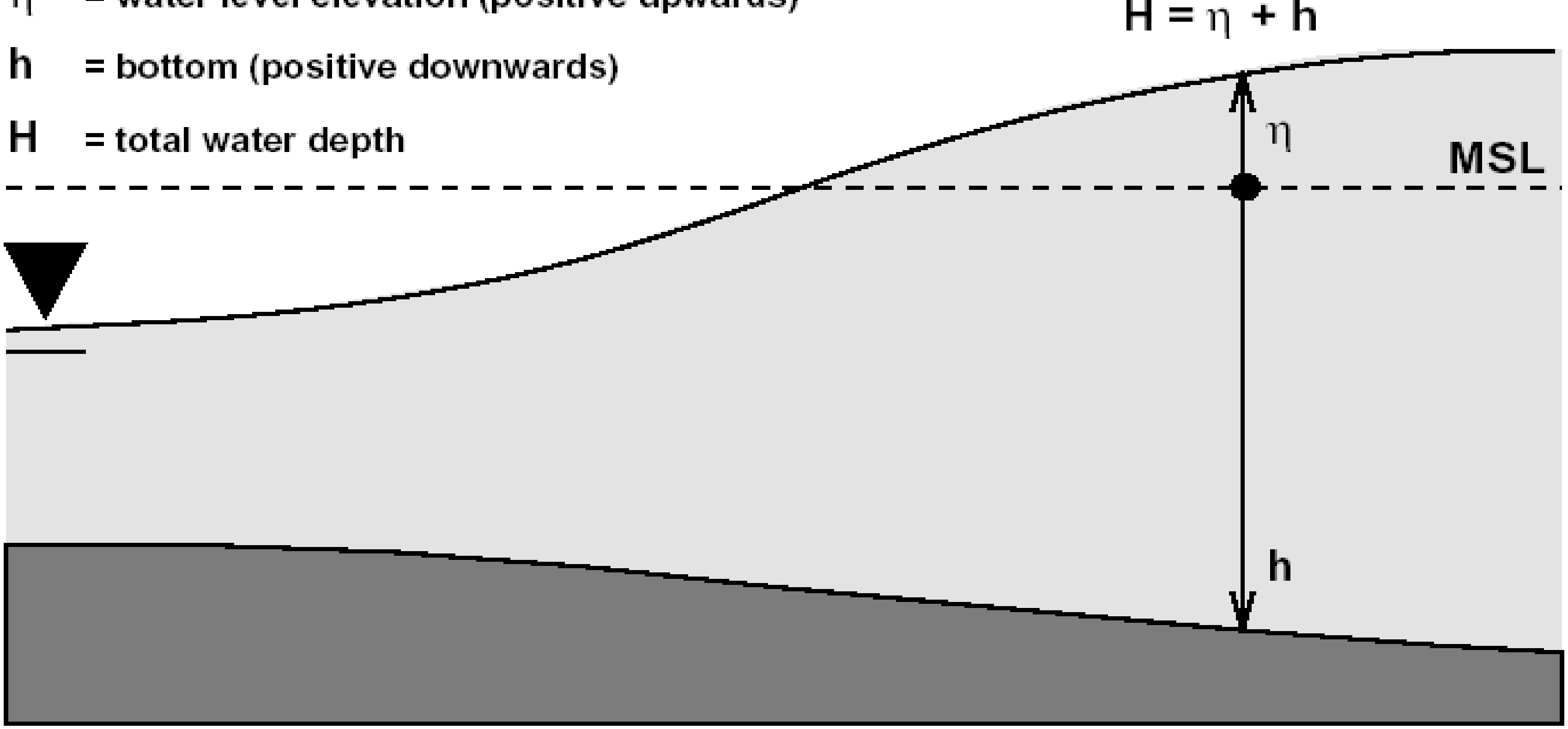
- Complicated geo
  (Unstructured or
- Can be both used
- Hydrostatic and
- No Coordinate T
- Efficient and Ro
- Computational c
- Wetting and dry



η = water level elevation (positive upwards)

h = bottom (positive downwards)

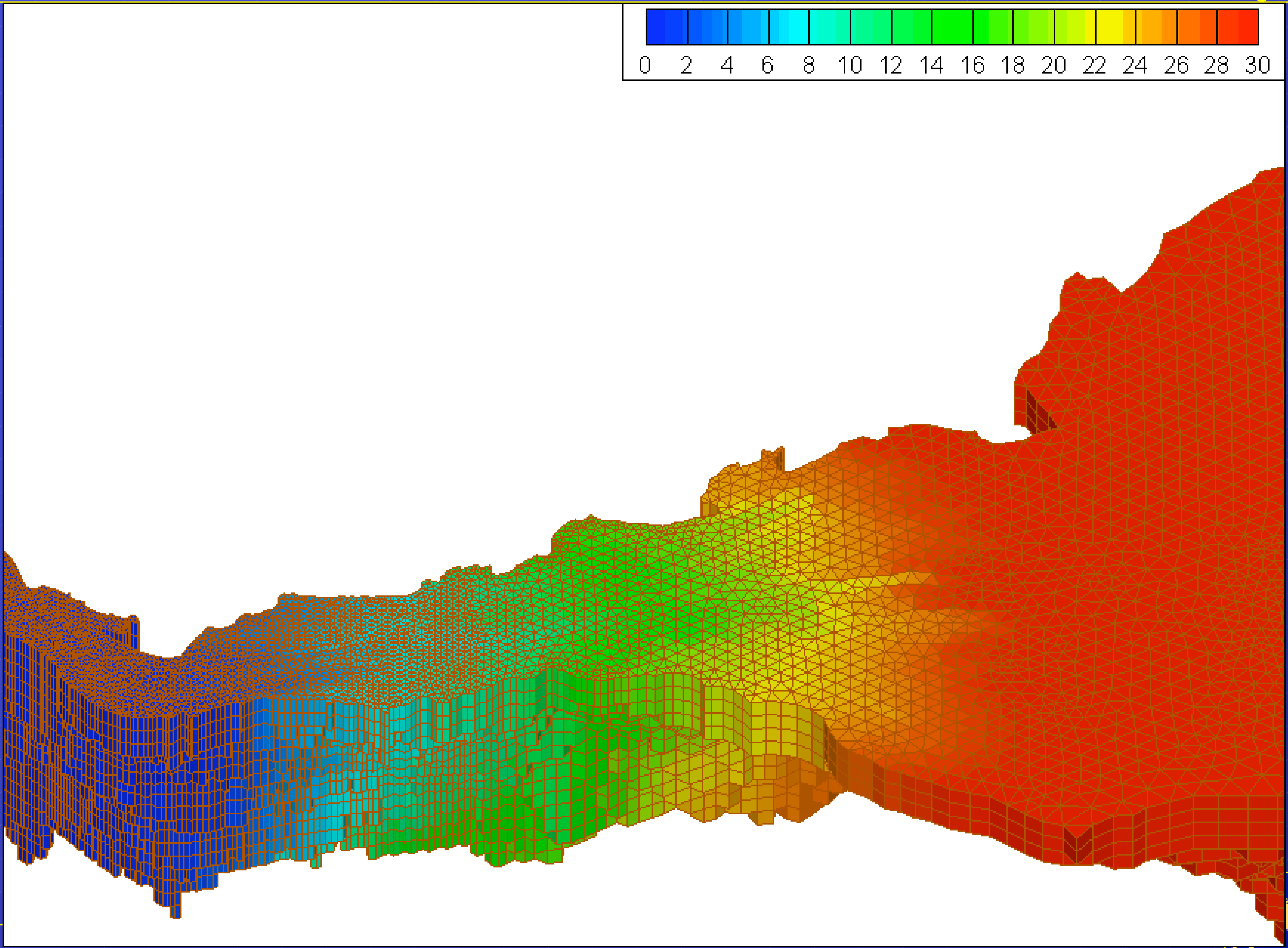
H = total water depth

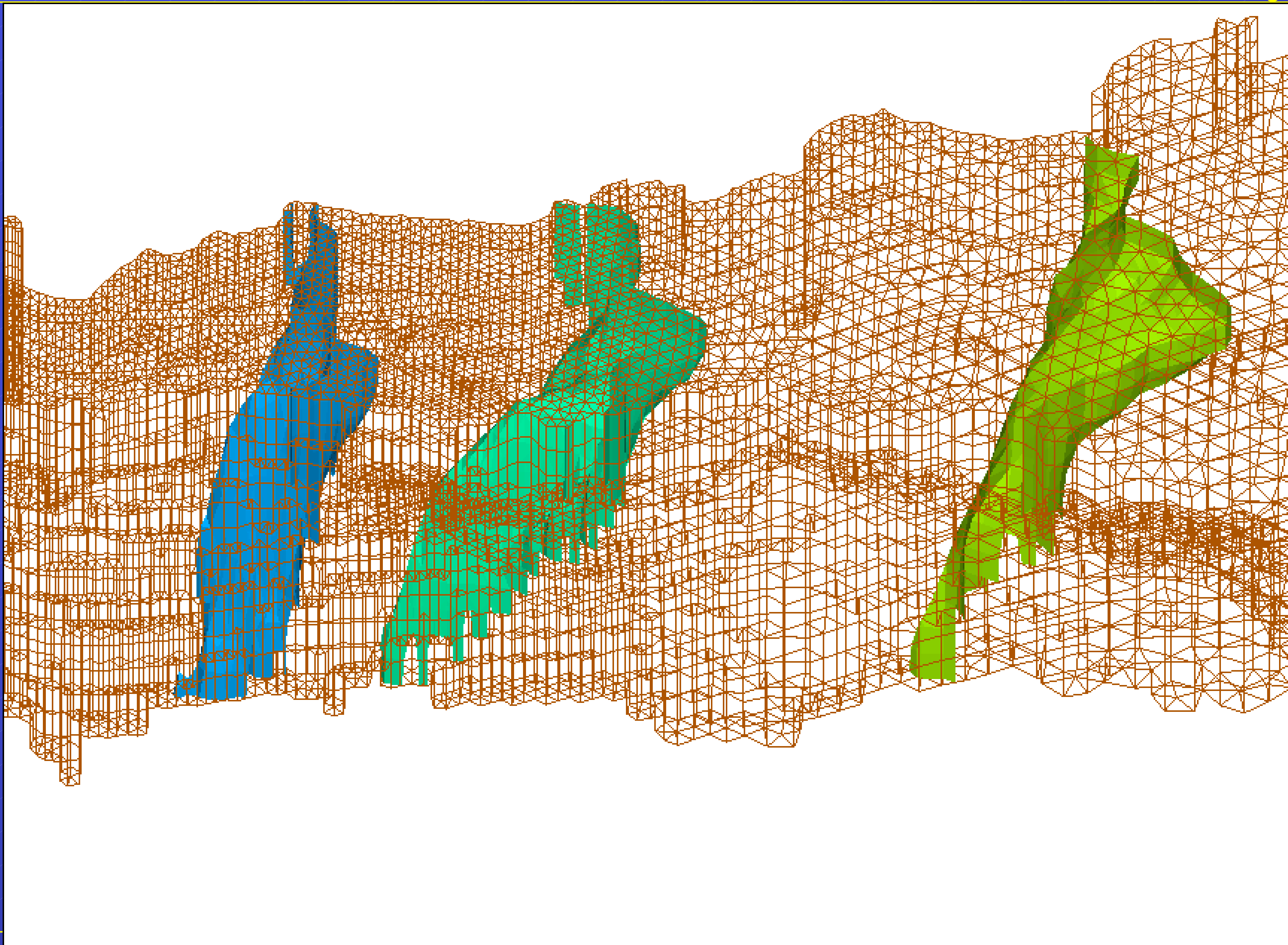


$$\frac{\partial \eta}{\partial t} + \frac{\partial}{\partial x}\left[\int_{-h}^{\eta} u dz\right] + \frac{\partial}{\partial y}\left[\int_{-h}^{\eta} v dz\right] = 0,$$

$$\rho = \rho(C),$$

$$\frac{\partial C}{\partial t} + \frac{\partial (uC)}{\partial x} + \frac{\partial (vC)}{\partial y} + \frac{\partial [(w^s)C]}{\partial z} = \frac{\partial}{\partial x}\left(K^h \frac{\partial C}{\partial x}\right) + \frac{\partial}{\partial y}\left(K^h \frac{\partial C}{\partial y}\right) + \frac{\partial}{\partial z}\left(K^v \frac{\partial C}{\partial z}\right),$$


0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30



Turbulence Closure

- The GLS model solves a transport equation for turbulent kinetic energy ( ) and a transport equation for a generic parameter ( ).
- The generic parameter is defined by:

Generic Length Scale Method

Depending on the value of *p*, *m* and *n* the parameter takes the form of different turbulent closure parameters like etc.

Computation Time

- CPU time / Real time ratio on a single processor 1/10~80
- Meaning that for 1 hr computing you are simulating 10hrs to 3.3 days of physical process.
- OK for short time simulations ~ weekly or monthly
- How about seasonal or yearly simulations?

Transport of Scalar Quantities

- Salinity, Temperature, Turbulence Param. (4)
- Drinking water – Contaminant transport.
  - More than 20 different species
- Sediment Transport
  - different type of bed materials (?)

Parallel Processing

- CPU time / Real time ratio on multiple processors 1/10~80 * N * e
- Physical processes which are expensive can be simulated (Sediment , Contaminant transport)
- Seasonal or yearly simulations can be done

  – Question: MPI or OpenMP
  – Answer: OpenMP easy to implement-not scalable
    MPI -difficult to code

Questions?